HERBICIDES

General Aspects
of
Chemical Vegetation Control

Ministry of the Environment
Ontario

PESTICIDES CONTROL SERVICE

Environment Ontario

H E R B I C I D E S

GENERAL ASPECTS

OF

CHEMICAL VEGETATION CONTROL

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MINISTRY OF THE ENVIRONMENT

02-003

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MINISTRY OF THE ENVIRONMENT

PESTICIDES CONTROL SERVICE

GENERAL ASPECTS OF CHEMICAL VEGETATION CONTROL

1. WEEDS AND THEIR ECONOMIC IMPORTANCE

The responsibility of producing food rests basically with agriculture and the agricultural worker. Only sixty-five years ago one agricultural worker produced enough agricultural products for ten other persons; today one agricultural worker is capable of sustaining thirty other persons. In addition, the quality of the product he now produces is far superior to that of thirty years ago. Technological advances which have produced herbicides have played a part in the fantastic advances made in this direction.

Some authorities mention figures in billions of dollars as the annual loss in Canada due to pests - insects, diseases, rodents. Both United States and Canadian authorities state that weeds cause greater losses (crop production, etc.) than all other hazards put together. In addition to agricultural losses, we can think of weed losses to the city lot owner, (weed problems on his lawn and gardens) public parks and other recreation areas, right-of-ways of highways, railroads, telephone, electric power transmission, industrial plants, the aquatic problem of lakes, ponds, ditches, tidewater areas; public health (hay fever, poison ivy). If these losses were put into dollars and cents the figures would be astronomical.

2. CHEMICALS

Chemicals used as herbicides vary widely in their properties. Many early chemicals were byproducts of the chemical industry or compounds of very low value. Examples are arsenic trioxide, a smelter waste; iron sulphate, a byproduct of the steel industry and waste oils of low value. In contrast with these chemicals, the new organic compounds that have come into use within the last twenty years are higher cost materials but they are also much more effective. Instead of acting en masse with the protoplasm (contents of the living plant cell), as oils do, most of the newer compounds act on or through the enzyme (a plant chemical used in the breakdown of plant food) systems in plants and hence are required in smaller quantities.

Although a considerable number of the newer herbicides may affect plants by blocking enzyme production essential to plant growth, only a few modes of action, such as dalapon which inhibits enzyme production and substituted urea which prevents plants from releasing oxygen during photosynthesis have been determined with any degree of accuracy.

3. CHEMICAL CLASSIFICATION OF HERBICIDES - See Appendix "A"

Organic Herbicides

A - Phenoxy compounds

B - Phenolic compounds

C - Carbamates

D - Acetamides

E - Thiocarbamate

F - Substituted Urea

G - Triazines

Inorganic Herbicides

Miscellaneous Compounds

The above chemicals are grouped according to chemical relationships and may be separated into selective, non-selective herbicides and soil sterilants. A selective herbicide is one which will destroy only specific plants while a non-selective or general herbicide will kill all plants it comes in contact with. These two types of herbicides may also be divided into the three ways in which the chemicals may perform, A - Contact B - Translocate C - Soil treatment.

A - Contact herbicide is one which kills the leaves and sometimes the plant at or very close to the area of application. This herbicide must be thoroughly applied to the foliage of the plant so that it may kill the growing tips and the leaf axils of the foliage.

B - A selective herbicide of the translocated type must penetrate the leaf and move down the plant to the roots. The first material of this general type to be used as a weed killer was 2,4-D.

C - Soil treatment is the application of the chemical to the soil so that the plant will absorb it when taking in water.

Acetic Acid Series (2,4-D etc.)

2,4-D, 2,4,5-T, and MCPA kill seedling, susceptible plants chiefly by being translocated from the point of entry into the root systems. They are selective against many broadleaf weeds in cereal and grass crops. Although they may be absorbed from the soil by very young seedlings their action is mainly by being absorbed by the leaves and then moved throughout the plant.

Phenoxy herbicides are generally non-toxic to man and animals and are cheap and potent chemicals, capable of controlling weeds at a low cost. 2,4-D has great versatility in its uses, which range from weed control in various crops to control of aquatic vegetation. 2,4,5-T has proved more effective than 2,4-D against many woody plants, however its application has been restricted.

The complete action of a phenoxy herbicide involves the penetration of the plant, the migration of the chemical to the root system and finally the toxic action. The chemical disturbs the normal growth of plant cells causing the plant to grow much faster than normal which will result in plant distortion and death.

4. PLANT IDENTIFICATION

The two main groups of plants which may be killed or controlled with herbicides are grasses (monocotyledons) and broadleaf species (dicotyledons).

Twitch grass (Quack) and green foxtail are examples of weedy grasses. Dandelions and wild mustard are examples of broadleaf weeds. Trees and shrubs may also be classified as broadleaf weeds in brush control programs. Water weeds of grassy and non-grassy types including the tiny green cells and threads of algae are another special problem.

Selection of the best herbicide for a particular weed problem depends upon the particular weeds and where they are growing. Some broadleaf plants may be susceptible (sensitive) to one herbicide and resistant to another one. You should therefore know the individual species of weeds that are present, and what herbicides are most satisfactory for their control. Annual weeds which have shallower and simpler root systems are easier to remove than perennial weeds. Where mixtures occur there is little or no advantage in killing one type of weed if others are then able to dominate.

When you want to kill weeds in a crop and harm the crop as little as possible, you need a selective herbicide. Since a selective herbicide may kill one kind of weed and not injure some other type growing with it, you may have to use a suitable mixture of selective herbicides to kill the various weed species without damaging the crop. You must, therefore, know the type of crops each herbicide is recommended for and follow the label directions as to rate of application and stage of growth.

If you want to kill all the vegetation in areas such as roadways or industrial sites, a general or non-selective herbicide will usually be the best choice. There may be situations where it is best to clean up an area most efficiently and economically. You can make better decisions about safe, proper and least expensive use of herbicides if you are familiar with some of the main aspects and variations of herbicidal activity relative to various weed problems.

5. PENETRATION OF SELECTIVE HERBICIDES

A chemical is useless as a herbicide unless it is prepared and applied in the proper way to help it penetrate the surface of the weeds. Appropriate emulsifiers, wetting and sticking agents, must therefore be used in order that the spray forms an even film on the leaves and does not run off or dry up and disappear into the air. Such substances are usually added at the factory but sometimes where there is difficulty in securing satisfactory coverage of dense brush for example, the addition of a small amount of household detergent (Vel, Duz, etc.) into the spray solution may help. The need for added wetting agents can be determined by inspection to see whether the spray is collecting in undesirable large separated droplets on the leaves.

Spraying on very hot, windy days often gives poor results because much of the chemical evaporates or blows away. These conditions also increase the risk of damage to neighbouring crops, gardens, trees, and flowers caused by chemical volatility and spraydrift.

Part of the reason for selectivity of herbicides is that some plants hold the spray better than others because of the position or type of their leaves. Some plants have waxy leaf surfaces with many small ridges. Water solutions stick only to a small part of these surfaces. Leaves of grasses are narrow and stand upright. Droplets of spray are therefore not easily held. Leaves of broadleaf weeds, on the other hand, are wider and grow out horizontally from the plant so that they can hold more spray. Oils have properties which enable them to dissolve, and penetrate the waxy coverings of plants. That is part of the reason why ester formulations of 2,4-D, which contain oil, are somewhat more effective than other formulations and require very close attention to instructions for use in lawns.

It should also be pointed out here, that some species of broadleaf weeds are resistant to one chemical and not to others. For example, mouse-ear chickweed is resistant to MCPA not to mecoprop or dicamba in lawns. As mentioned in an earlier section the names of the weeds should be determined and the susceptibility lists consulted before deciding which herbicide to use.

The location and protective cover of youngest growing regions of leaves, stems and flowers also influence entrance and activity of herbicides. New cells of growing points and regions (meristematic tissues) are more delicate and more easily injured by herbicides than are the older, tougher parts of the plant. The growing regions of grasses are enclosed by the bases of older leaves, and protected in the crown of the plant below the soil level. This is, of course, a characteristic which enables grasses to recover from grazing or cutting. Broadleaf weeds, on the other hand, have exposed growing points at the tips of the shoots and have buds in the angles where leaves join the stem. Consequently they are more readily hit and killed by spray treatment.

6. ACTIVITY WITHIN THE PLANT

Growth regulators are often referred to as growth modifiers, growth substances, translocated herbicides, systemic herbicides. To this group belong 2,4-D, MCPA, 2,4,5-T, which includes acetic, butyric and propionic types, as well as ester, amine and salt formulations for each. The 2,4-D and MCPA group are by far the most widely used herbicides.

We have noted some of the physical characteristics of plants contributing to differential selectivity of herbicides. With plant growth regulator herbicides like 2,4-D, physiological difference between species of plants are of major importance. For example, plantains are resistant to dicamba but very susceptible to 2,4-D. The reasons for biochemical selectivity and toxicity are still not well known despite extensive research work on the subject over the past twenty years. Resistant species are either relatively immune to the herbicide or can break it down without ill-effects from the conversion products. In cells of sensitive plants, their food manufacturing processes involving the green substances (chlorophyll, important in photosynthesis) and the utilization reactions (respiration) and storage of food mechanisms are affected in one way or another. Activity of enzymes and the formation, movement and use of sugars, proteins, fats, etc. may be greatly disturbed. The net result is that the physiological and biochemical processes become disrupted and cell growth becomes disorganized. Roots may appear from the upper stems. The plant may become curled, twisted, swollen, stunted, and split open. Movement of nutrient materials from the roots, leaves and stems is altered or blocked off. Flower and seed production may be abnormal or absent. The plant may die a lingering death from toxicity and gradual starvation during a period of several weeks.

Since gradual death of the treated plants is the normal result of effective application of 2,4-D, MCPA, mecoprop, 2,4,5-T, dicamba and similar plant growth regulator herbicides, there is no point in trying to speed up the kill by adding other chemicals which rapidly "burn" the plant parts. They will simply prevent the hormone type herbicides from moving as it should, extensively through the plant body. This movement, or translocation, is particularly important for maximum effects on deep rooted perennial weeds like Canada thistle and poplar brush. For the same reason it has sometimes been found that two split applications of 2,4-D were more effective than a single treatment at a dosage equal to that of the combined separate treatments. Sometimes, too, a relatively light dose of amine formulation has apparently been as effective, or more effective than a too-heavy treatment with the faster acting ester formulations. This statement is not intended to detract from the importance of ester. In general they have been the most extensively used formulations because of their effectiveness under difficult weather conditions against hart to kill annual weeds past their most sensitive stage of growth and against most herbaceous perennials and brush. Precautions regarding dangers from use in susceptible crops, hazards from over-dosage in any crops and safeguards from evaporation and drift to susceptible neighbouring crops are important with all formulations, but particularly so with ester. Use of the amines avoids this difficulty insofar as vaporization is concerned, therefore their use in lawns near susceptible crops or ornamentals is advised.

All of these herbicides seem to work best when conditions are good for active growth favoured by adequate soil moisture and warm but not too hot weather. Young annual weeds in the seedling stage are easier to kill than

older ones. This is because the young plants have a major proportion of sensitive new growing tissue. Herbaceous perennial weeds are often most susceptible near their flowering stage. Their root reserves for regrowth are often least at this time. Woody perennials are most sensitive to spray treatment just after they come into full leaf. Later they become rather tough and resistant. You should consult available extension bulletins for details concerning various crops and weeds, such as publications 75, 448, 529 and 550, published by the Ministry of Agriculture and Food.

7. "CONTACT" HERBICIDES AND THEIR ACTIVITY

In the foregoing discussion we referred to selective plant growth regulator herbicides which after entrance into plants, move to other parts of the organism to cause various types of disturbance and gradual death.

The "contact" herbicides are in another major category of herbicides which act in a different way. They ordinarily have little or no movement (translocation) within the plants. The reason is that they almost immediately kill the plant cells with which they first come into contact by a sort of 'burning', 'scorching', or 'curdling'. That is why they are called contact herbicides. The severely damaged or dead cells are unable to carry on as a part of the chain of growth manufacturing and communications processes. Hence the herbicide stays at the point of contact. Consequently with this type of herbicide, it is extremely important to achieve thorough coverage of the entire surface of plants which it is desired to kill.

Adequate volumes of water and a wetting agent are necessary for minimum activity of contact herbicides. With perennial weeds the tops may be killed but regrowth usually occurs from the roots. This type of herbicide is therefore generally used for a quick knock-down. For example, in garden crop land before the crop emerges, or for temporary general top-killing along roadsides and in waste places. It may make it easier to burn off the vegetation afterwards. Some of these herbicides, for example, paraquat and diquat, have been used to set back old pasture grasses and weeds by burning and stunting, while giving new seedlings of better species a chance to get started. Diquat, paraquat and gramoxone are largely inactivated as soon as they contact the soil and litter, so there is no residue problem. Results for pasture work has been promising in this country, and diquat and paraquat can be used for controlling top growth of undesirable vegetation around trees and shrubs and along fence lines and patios. Consult the label for other uses. Certain species of aquatic weeds may also be killed by diquat applications.

There are also contact killer oils such as Diesel fuel and "aromatic" oils which at rates of 10 to 20 or more gallons per acre are toxic to grasses as well as to broadleaf weeds. Light herbicidal oils such as Stoddart solvent and Varsol, used under proper conditions are selective in control of weeds in crops of the carrot family. Apparently the selectivity in this case is due mainly to different characteristics of the cell protoplasm (protein organization) and not to the differential wetting and retention on the surface of weeds and crop. As noted earlier, the kind and amount of oil used as a carrier in association with 2,4-D may affect the margin of safety when spraying weeds in crops. Consequently for very sensitive crops the use of up to 20 gallons of water per acre as the carrier, without oil, has been recommended to reduce the danger of injury to the crop.

8. SHORT-TERM "SOIL STERILANTS"

Certain other herbicides such as Dalapon, TCA, and sodium chlorate act **partly** as contact herbicides and partly as short-term soil sterilants. They retard or prevent new growth for different periods of time depending on the dosage, the soil type, activity of micro-oranisms in the soils, and temperature and rainfall after application. Heavy clay loam soils can inactivate by absorption more of the applied chemical than can light sandy soil. On the other hand, the herbicides leach down faster in sandy soil than in clay. These factors are important in deciding most suitable rates of application for the particular circumstances involved. For example, Dalapon and TCA are more effective on perennial grasses than on broadleaf perennial weeds.

9. LONG-TERM "SOIL STERILANTS" (FOR TOTAL VEGETATION CONTROL)

No chemical as yet has been developed which may be used economically to eradicate all vegetation for longer periods than 3 growing seasons. However, the maximum effectiveness can be obtained by ensuring that:

a) The chemical comes into contact with the soil. In some cases this may even require removal of the vegetation prior to treatment.

b) All plant species present be identified first, before any consideration is given to the selection of chemical for effective control or eradication of these species. This may require the use of mixtures of chemicals.

c) The chemical or chemicals be applied before the grand period of growth.

Dead vegetation creates a fire hazard, particularly in forested areas; but this may be overcome by either applying the chemicals prior to the start

of the growth, cutting and disposing of the existing vegetation before treating and applying chemicals which do not promote a fire hazard. Also numerous soil factors may be involved here, such as a large number of plant species and climatic variations. This may result in an enormous complex herbicide - soil, weed, weather interactions, etc. that will make "specific recommendations" difficult to achieve. Soil penetration to the root zone is an important feature in the action of chemicals for control of vegetation. The following factors often influence the rate and amount of penetration:

a) Compaction of surface layers

b) Absorption surfaces - clay, ash, etc.

c) Uneven surface drainage

d) Low surface moisture content at the time of application

e) Low rainfall.

These features are typical of many sites and are often the reason for escaped weeds such as horsetail, milkweed, field bindweed and Canada thistle, dominating treated areas.

Certain weak species survive and/or readily re-establish themselves from seeds on treated sites; for example, plantain on diuron treated sites, crabgrass on atrazine sites, oxalis on prometone treated sites and vetch on simazine treated sites. Regrowth on treated areas includes those plants that are not eradicated because of insufficient penetration of the chemical to the soil; also because the plants are resistant to the particular chemical being used, plus those that rapidly re-establish themselves from seeds. Such species can often be eradicated by other herbicides.

10. WARNING

Some of these chemicals may kill trees and shrubs if their roots extend under the treated area, and thus come in contact with the herbicide as it penetrates the soil. If the area being treated is sloping, some of the chemicals may 'wander' from the area of application, thus injuring or killing vegetation beyond the treated area.

Contact or hormone-like herbicides may be added to a residual herbicide to improve the control of vegetation during the first season, e.g. diquat, paraquat, 2,4-D, amitrole, chlorates, dinoseb. Some mixtures have been registered and can be recommended.

11. PRECAUTIONS IN USE OF HERBICIDES

As with most pesticides, trouble arises not so much because of herbicide use but rather because of misuse. To avoid misuse, it is essential that herbicides be used with caution and that the right material be used at the proper rate.

A good starting point is the reading and understanding of the directions and precautions printed on the labels. Know what material is being used, what can be expected as far as weed control is concerned, and what effects the material can have on the applicator, on other forms of life, and other crops.

1) To protect the applicator:

a) Use the minimum rate of the least toxic material that will do the intended job.

b) Avoid over-exposure to fumes. Handle or mix volatile materials in the open.

c) Avoid over-exposure to possible spray drift and wear protective clothing, including rubber gloves and goggles, when handling or applying the more toxic herbicides.

Thoroughly wash any splashed materials from exposed areas of the skin. If herbicides have been splashed into the eyes, immediately wash with large amounts of clean water.

Wash clothing frequently, preferably each day after herbicides have been handled or applied. Clothes should be changed immediately if they become contaminated by spilled or splashed material.

d) Do not smoke or eat while handling or applying herbicides, and thoroughly wash hands and face before smoking or eating.

2) To protect other forms of life:

a) Store herbicides in original containers. Do not transfer to other containers unless properly labelled, and never use herbicide containers for storing other materials.

b) Keep open containers out of the reach of unauthorized persons, children in particular.

c) Never store herbicides near fertilizers, crop seeds, or other pesticides.

d) Destroy all containers when empty. Paper and cardboard containers may be burned, and metal and glass containers should be mutilated or broken and buried.

e) All possible care should be taken to keep children and pets off the treated area for several days or until rain or watering has removed the herbicide from vegetation into the soil.

f) Use extreme care when applying herbicides near water so that the material will not contaminate water containing game, fish or water used for drinking, cooking or irrigation. Do not wash or rinse spray equipment where the washings can get into such waters.

3) To protect other crops:

a) Use the least volatile material that will serve the intended purpose, particularly in the vicinity of built-up areas and near susceptible crops.

b) Keep spray drift from ground applications to a minimum by using increased volumes of water, selecting nozzles and pressures to increase droplet size, and making applications when winds are light (preferably less than 10 mph.)

c) Equipment for herbicide application should be used only for herbicides. If other pesticides must be applied with the equipment, extreme care must be taken to clean all parts of the equipment thoroughly, both internal and external (see Field Weed Sprayers, Ministry of Agriculture and Food, Publication 256 or Canada Department of Agriculture, Publication 1157).

PROCEDURES

1. The rates of treatment for the various herbicides are based on their acid equivalent or active ingredient unless otherwise stated.

2. Whenever systemic herbicides such as 2,4-D, 2,4,5-T and MCPA are used, there is danger of spray, dust, or vapour drift. Therefore, when such herbicides are used in the vicinity of susceptible crops, gardens, and shrubs or tree plantations, suitable precautions should be taken to prevent drift of spray or vapour etc., and the salt forms (sodium or amine) or low volatile esters should be used.

3. When applied in excessive quantities, 2,4-D and MCPA will kill a very wide range of plants. Warning is therefore given not to apply rates higher than the maximum recommended for the respective chemicals uniformly.

4. It is recommended that receptacles, containers, and machines used for applying systemic herbicides, should not be used for the application of fungicides and insecticides on susceptible crops. If they must be used, thorough cleaning is necessary. Rinse with water containing a small amount of detergent, fill with a weak solution of household ammonia and allow to stand overnight, drain and rinse thoroughly with water.

5. Do not store systemic herbicides close to seeds, fertilizers or other pesticides.

6. Soil sterilants, such as monuron, simazine and chlorate and borate compounds, frequently will kill trees and shrubs that are located near the treated area but whose roots extend under the treated surface and come in contact with the herbicide as it penetrates the soil. This probability should be considered carefully when using these chemicals.

7. Some herbicides may remain in the soil in toxic quantities for long periods. The exact length of time depends on original quantity applied, soil moisture and temperature, amounts of cultivation and, perhaps, other factors. Consideration of possible residual effects should be given before planting a crop that is highly susceptible to a particular herbicide, in a field previously treated with that herbicide.

12. WHEN TO APPLY

Time of herbicide applications must be taken into account with growth stage of the weeds and/or the crop, differences due to season, daily patterns of light, temperature and humidity, as well as such variable factors as wind, rain and cloud. The relative importance of these factors will depend on the herbicide to be used, i.e. selective vs. non-selective. While herbicides differ widely in their mode of action, related compounds are usually quite similar and therefore the above factors can be discussed on a group basis.

Annual weeds are more effectively killed if the phenoxy, benzoic or phenylacetic compounds are applied when these weeds are in the early stage of growth. The phenoxy and benzoic compounds can be used in this way to replace part of tillage required on fallow.

Woody plants are most susceptible when the leaves become fully expanded. Treatment of most woody species would therefore be done during mid-June to mid-July. If applied when dormant, use oil as the carrier or at least use some oil instead of water alone. Frill, notch and basal bark or stump treatments are effective at any time of year.

Light intensity, temperature and humidity affect penetration, movement and activity of the phenoxy and benzoic herbicides. However, it has been difficult to show real benefits from spraying grasses at only specific periods in the day. On the other hand, the value of <u>not</u> spraying woody species during the hottest part of the day has been fairly well established, because of the fact that the waxy leaf cuticle tends to slow penetration and consequent losses due to evaporation often result. If volatile, 2,4-D esters are being used the hazard of injury to surrounding susceptible crops increases with increasing temperatures.

Wind and rain are limiting factors to spray operations. Winds in excess of ten mph. will create the hazard of spray drift to nearby susceptible crops while winds in excess of 15 mph. will often distort spray pattern and result in uneven application.

APPENDIX "A"

CHEMICAL CLASSIFICATIONS OF HERBICIDES

Organic Herbicides

A. Phenoxy Compounds

a) Acetic acid series

2,4-D*	Available as amine and sodium and lithium salts and esters.
MCPA*	Available as amines, esters and sodium and potassium salts.
2,4,5-T*	Available as amines and esters. Restricted for use in Ontario, (See T.M.-88)
disul* (sesone)	

b) Propionic acid series

dalapon*	Usually formulated as the sodium salt.
erbon*	
mecoprop* (2-MCPP)	
fenoprop* (Silvex)	

c) Butyric acid series

2,4-DB

MCPB*

Other Organic Acids

chloramben* (amiben)

dicamba* (Banvel D)

endothall*

naptalam*

picloram

2,3,6-TBA

TCA*

* (Common Names Accepted by Canadian Standards Association).

B. Phenolic Compounds

bromoxynil*

dinoseb* (DNBP)

Formulations of dinoseb

a) phenol

b) ammonium salt

c) amine (alkanolamine salts)

DNOC*

ioxynil*

C. Carbamates

barban*

chlorpropham* (CIPC)

propham* (IPC)

D. Amides

CDAA

CDAA-T

diphenamid*

propanil* (DPA)

solan*

E. Thiocarbamates

CDEC

diallate*

EPTC (Eptam)

metam* (Vapam)

PEBC (Tillam)

triallate*

*(Common Names Accepted by Canadian Standards Association).

F. Substituted Urea

chloroxuron*

diuron*

fenuron*

linuron*

monolinuron*

monuron*

OMU

Urab

G. Triazines

atraton*

atrazine*

simazine*

prometone

prometryne*

H. Inorganic Compounds

a) Chlorates

=active ingredient is sodium chlorate.

Sodium chlorate* is inflammable but can be used to advantage if proper precautions are taken. Some available formulations contain a fire retardent and are consequently safer to use. Adequate precautions to prevent fire should be taken for 2 weeks or more after spraying. Rates given are for actual sodium chlorate. More than one brand containing a fire retardent should not be mixed in a sprayer as the additives may form a precipitate. These materials are poisonous and are attractive to salt-hungry animals.

b) Copper sulphate

=Algacide-concentration of 3 ppm or higher is toxic to fish and mammals.

c) Borates

=There are numerous products available that contain boron although only a few contain boron as the sole active ingredient. Mixtures of borates with other herbicides are available. The proportions in the mixtures vary rather widely between products. For a complete list, consult the "Indices and listings of Canadian Pesticide Registrations" prepared by the Plant Products Division, Canada Department of Agriculture, Ottawa, Ontario.

I. Miscellaneous Compounds

AMA	= Ammonium methyl arsonate (total arsenic 4%).
amitrole*	
amitrol-T	
bromacil*	
calcium arsonate*	= Available products vary in arsenate content.
calcium cyanamide	= Formulated in powder and granular form.
DCPA (Dacthal)	
dichlobenil	
diquat*	
DMA	= Disodium methyl arsonate (arsenic eq. of available products varies widely).
DMPA (Zytron)	
DMTT (Mylone)	
EXD	
isocil*	
liquid cyanamide	= Formulated as hydrogen cyanamide 25%.
paraquat*	
PMA	
potassium cyanate*	= Products range from 53-92% potassium cyanate.
pyrazon* (PCA)	
sodium arsenite*	= Available products vary in sodium arsenite content.
trifluralin*	

* (Common Names Accepted by Canadian Standards Association).

REFERENCES

This booklet has been based on the 1967-68 Herbicides Correspondence Course, Lessons 1 and 2 prepared by Dr. C. M. Switzer, Botany Department, University of Guelph and Mr. J. G. Kurys, Technical and Education Consultant, Pesticides Control Service, and revised by Mr. R. P. Cameron, District Pesticides Officer, Ministry of the Environment.

Revised by Mr. J. G. Kurys in 1972.

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The Ministry of the Environment would like to thank Mr. E. G. Anderson, Scientific Information Section, Canada Department of Agriculture, Ottawa, for this generous contribution and supervision in the preparation of this booklet.